Solar Parking Lot Analysis: Smart Investment or Waste of Capital

Jared J. Davis
California Polytechnic State University San Luis Obispo
San Luis Obispo, California

In the last couple decades solar panels have been developed into a sustainable and effective method for harnessing clean energy. Today, solar panels have been engineered into solar roadways. Solar roadways are structurally engineered solar panels which can be installed in the Earth, driven on, and can replace the need for traditional asphalt roads. These solar roadways also include built in LEDs which mimic road lines and light up wildlife crossing the road, making these road panels a very safe alternative to traditional asphalt roads. This senior project is an analysis of solar roadways and their capabilities when applied to parking lots. It will specifically test how effective a solar parking lot will be when installed in the local San Luis Obispo Costco parking lot. In the end, a feasibility evaluation will determine if a solar parking lot will save more money than it costs. A critical literature review and energy analysis have been conducted to acquire the most important and relevant information to conclude whether solar parking lots could be the future. Industry professionals, who have many years of experience working with solar, and have shared their knowledge on this topic. The implementation of solar parking lots could effectively reverse energy consumption for businesses.

Key Words: Solar Panels, Solar Roadways, Sustainability, Energy, Costco

Introduction

Solar roadways are an innovative method for harnessing solar energy and using said energy to power local homes, industrial, and commercial buildings. This renewable energy replaces the need for fossil fuels from asphalt roads, which release tons of greenhouse gas emissions into the atmosphere every year. According the Environmental Protection Agency (EPA), greenhouse gasses released by households, industrial buildings, and commercial buildings have increased by over 77% since 1990 (Climate Change Indicators, 2016). Installing solar parking lots in commercial business areas could greatly reduce the amount of greenhouse gasses released each year.

Many giant retailers in the United States are setting the tone for renewable energy standards. Costco is among one of the major forward-thinking companies which strives to build with an emphasis on diminishing its carbon footprint. Already, Costco designs all its building to use over 76% recycled material, including reflective roofing to reduce heat gain, and installing efficient LED lighting which saves over 110 million kilowatt-hours (kWh) per year (Costco Sustainability Building, 2018). Since they are always looking for more ways to be the leaders in sustainable practices, Costco could be the progressive company to set the bar for sustainable commercial building standards by installing solar parking lots in some of their locations.

Objective

Solar roadways are a relatively new innovation which have some extremely effective applications that should be further examined, as they have not been given the attention they deserve,. The purpose for this analysis is to better understand how solar roadways operate and determine their effectiveness on a smaller scale, specifically parking lots of commercial buildings. Many sustainable scholars have published about solar roadways, but most only

concern themselves with their capabilities and cost, while ignoring their overall effectiveness. This analysis will evaluate how effective these panels are with harnessing the required amount of solar energy needed to sustain Costco and their return on investment (ROI) to conclude if the investment is worth it, or a waste of time and money.

Methodology

There were several methods of data collection used to compile the necessary information for this analysis. To accurately determine the efficiency levels of solar road panels, quantitative data was the most crucial, as it provides hard numbers, which were used to effectively determine the amount of electricity these panels can produce. Quantitative data was critical when evaluating Costco's sustainability report, since those numbers were essential in determining how much energy the panels need to produce to cover Costco's yearly energy output. The company, Solar Roadways Inc., whom created the idea for these panels, have also provided important information on cost, efficiency, and future expectations.

Background Information

History of Solar Roadways

In recent decades, harnessing solar electricity has become one of the most rapidly growing sources of renewable energy. In the 1970s, solar panels were not very efficient, only generating about 7.5% of the solar energy they were exposed to (History of Solar Energy, 2018). Since then, many companies have studied solar panels and developed them to become more efficient and cost effective. Due to all the research and development, solar panels today have an efficiency rating of about 23% (History of Solar Energy, 2018). In more recent years, companies have worked on new ways to utilize solar panels to harness more renewable energy. Among these innovations, are solar roadway panels. Which are solar panels that are engineered to be driven on, while collecting clean energy from the Sun.

The company streamlining the development of these solar panels is Solar Roadways Inc. Started in 2006, the owners have a passion for sustainability and are dedicated to evolving solar roadways into the new standard for road and highway building. Their first successfully working prototype was completed in 2010, and since then the company has released three different types of panels which continue to become safer, less expensive, and more efficient. Starting with the intention to install these panels in roadways, they quickly realized how many applications solar roadways had. Solar Roadways Inc. then began to test them in other areas, most notably, sidewalks and parking lots (Solar Roadway Specifics, 2016).

Panel Engineering

The solar roadways are essentially specially engineered solar panels which consist of three main layers:

- The road surface layer
- The electronics layer
- The base plate layer

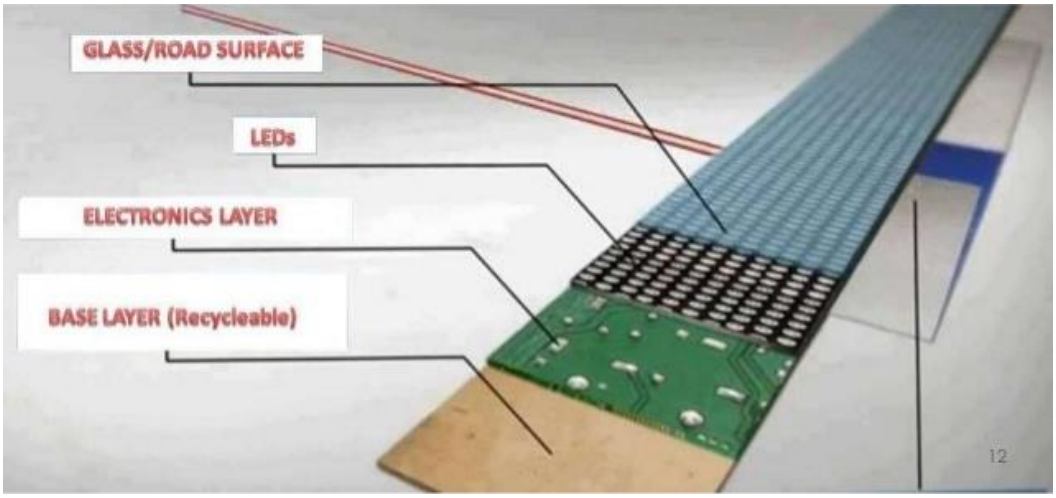

Figure 1 - Solar Roadway Layers

The road surface layer, or otherwise known as the glass surface, is a structurally tempered glass material, designed to withstand the weight of moving vehicles. After being tested, it was concluded that the glass could resist a load of up to 250,000 pounds, which is more than three times the weight of a fully loaded semi-truck (Solar Roadway Specifics, 2016). This layer also has a rough textured surface which provides the same level of traction for vehicles provided by traditional asphalt roads. The tempered glass also maintains it traction during heavy rain, proving that these panels are exceedingly safe under all driving conditions.

One of the most important and complex aspect of solar road panels, is the electronics layer. Essentially, this layer consists of photovoltaic cells, powered by the circuit board, which absorb the solar energy and convert it into electricity. The circuit board is then completely enclosed in glass, to protect it from any water damage. This layer is extremely important as it contains a microprocessor which communicates with surrounding panels so they are all working in unison. Another very important facet of the electronics layer are the LED lights, in which it powers. The LED lights illuminate the road/parking lanes, safety signals like “slow down,” and can even light up wildlife that are crossing the road.

The final piece of these solar road panels, and arguably the most integral, is the base plate layer. While the electronics layer is responsible for converting the solar energy into electricity, the base plate layer is in charge of sending that electricity to the power grid, where it is then distributed to commercial buildings and residential homes. Typically, when a business installs these panels in their parking lot, they also install an on-site power grid which will send all the electricity to that sole building.

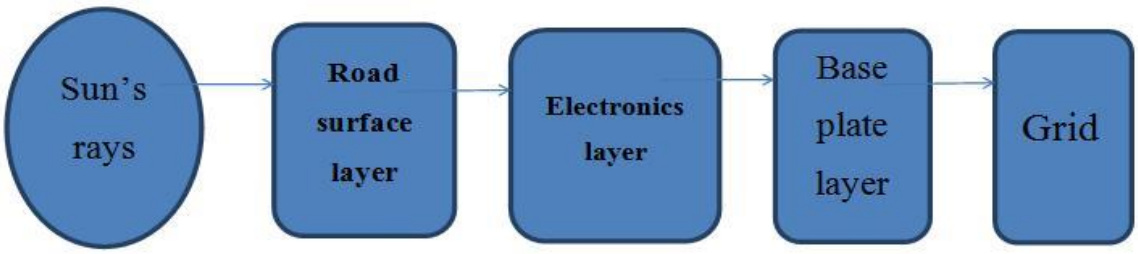

Figure 2 - Diagram of Panel Function

Features

Among solar road panels most attractive features is its easy maintenance and repairs. Unlike traditional asphalt roads which have lengthy maintenance schedules, solar road panels have been designed to be quickly switched out and repaired. Each panel weighs around 100 lbs. which can be removed, reinstalled, and reprogrammed by a single operator in a very short time (Solar Roadway Specifics, 2016). An incredible difference between solar road panels and asphalt roads is their life expectancy. Solar Roadways Inc. has stated the lifetime expectancy of these panels is between 20-30 years, compared to asphalt roads which have a life expectancy of about 7-8 years before needing serious repairs (Johny, 2017).

Another amazing feature of solar road panels is the ability to adjust the LED lights to instantly reroute road lanes. This is especially useful during road maintenance as is can be utilized to minimize traffic disruption. This ability to redirect traffic is very important to the maintenance operator as it helps keep them safe while they work. In parking lots, the LEDs light up parking lines, and parking signs such as "compact" or the handicap signal. If all the handicap parking spaces are filled up, the panels will sense that and activate the LEDs to quickly add another handicap parking spot, which can really benefit those with disabilities.

Real World Analysis

Efficiency

With the increase in demand for solar energy in recent decades, the research and development on solar panels has increased immensely, and the results are astounding. In general, solar panels have become over three times more efficient than they were almost 40 years ago. The same has occurred with solar road panels. In 2006 these panels could only obtain an efficiency rating of about 10%. Now, solar road panels are commonly achieving efficiency levels of 18.5%, which is a tremendous increase in such a short time (Solar Roadway Specifics, 2016). It is reasonable to assume these numbers will continue get better, but only time will tell how much more efficient these panels will become in the next few years.

One drawback of solar roadways, unlike regular roofing solar panels, is they cannot be angled to provide maximum efficiency. Industry professionals have tested and estimated the efficiency loss between roof panels and road panels to be somewhere between 25-31% (Solar Roadway Specifics, 2016). This is an unfortunate loss, but the same industry professionals believe this to be very miniscule when applied to a larger scale.

Costco's Application

On paper, solar parking lots sound like an incredibly innovative method for commercial buildings to harness solar energy, but it is still a wonder whether they are efficient enough to cover the initial investment. One way to determine this is by testing the efficiency over an area to see how much power the solar parking lot can generate. Here, we will test that by analyzing the local, San Luis Obispo Costco parking lot and the yearly energy demand for the building.

According to Costco's 2015 sustainability report, they average 823 kilowatts (kW) per hour (Costco Sustainability Building, 2018). An average work day for this Costco can range from 8-10.5 hours, and for calculation purposes we will use an 11 hour work day. This means Costco can expect to use 9053 kilowatt hours (kWh) per day. Multiplying that by 365 days in a year, and we can estimate that at most Costco is using 3.3 million kWh per year.

Now, we have to look at how many kWh this solar parking lot could theoretically produce every year for Costco. For our calculations we will use a typical 230 Watt (W) solar road panel which operates at 18.5% efficiency and has an area of 13.4 square feet (sf) in size. Also, from the takeoff in Figure 3 we can see that Costco's parking lot covers an area of 370,410 square feet. Dividing the area of the parking lot (370,410 sf) by the size of the panel and wattage (13.4 sf / 230 W), we can expect the panels to harness 6,358 kW per hour. We also have to consider that there are only about 4 hours of peak sunlight each day, which means roughly 1,460 peak hours per year. Next, we multiple the 6,358 kW by 1460 hours and we can figure that the solar parking lot will generate around 9.2 million kWh per year. Although, because there is an efficiency loss due to the panels not being at the proper angle, we have to subtract 31% to get a more exact measurement. This leads us to accurately estimate the solar parking lot will generate over 6.4 million kWh per year (Solar Roadway Specifics, 2016). Even with that loss in efficiency, we can still determine that a solar parking lot can harness almost twice the amount of energy needed to cover Costco's yearly energy consumption.

Figure 3 - Costco Parking Lot Takeoff

Cost

Just like a highway, solar road panels are a sizable investment. Unlike highways, solar parking lots begin to see a return on the investment almost immediately. As of now, Solar Roadways are quite costly, with an estimated cost of $48 per square foot (Interview, 2018). To install these panels in the parking lot of Costco would come out to around $17,780,000. Putting this into perspective, asphalt cost about $4.00 per SF, which would come out to be $1,481640 (How Much, 2018). Although the life expectancy of solar road panels is three times more than the life expectancy of asphalt, it is still a much cheaper and more readily available option.

In San Luis Obispo, Pacific Gas & Electric (PG&E) charges $0.14 per kWh. Which means for Costco, their energy bill comes out to a yearly cost of about $465,000 (Pacific Gas & Electric, 2017). Even though solar parking lots are an enormous investment, Costco would begin to see their energy bill diminish to zero almost instantly.

Not only can businesses cut energy cost to zero, municipal companies like PG&E will you pay for the excess energy stored in said businesses power grid. Although, that payment is quite small, only about $0.04 per kWh, by the end of the year Costco could receive a return of almost $125,000 per year from PG&E (Getting Credit, 2018). That return, plus the money they save from eliminating all their energy cost would equal an upwards of $586,000 per year in savings. With a yearly return of this amount, we can estimate the full return on investment (ROI) would be around year 30.

Final Results & Conclusion

Solar roadways have been a controversial topic for some time, with most believing that it would be a waste of time, resources, and money. After evaluating the efficiency, possible amount of energy to be harnessed, and cost it can be determined that this analysis supports the claim that, as they currently stand, solar road panels would be a massive investment that would not see a full return for some time. With a lifetime expectancy of 20-30 years, and an ROI of 30 years, we can suggest that Costco should not consider investing in a solar parking lot. As technology continues to develop, solar roadways could become cheap and efficient enough to speed up the ROI and make solar parking lots an investment worth considering.

Future Research

Even though this analysis indicates that solar road panels are not a smart investment, there is still much research and development to be done on these panels. As time goes on, and more companies start to manufacture these panels, they will become more efficient and much more cost feasible. If another student decided to pick up on this research, I would recommend they work with Solar Roadways Inc. to check their progress on how they've modified their solar panels and how those panels perform in the future. Or a student could analyze the solar roadway installation on the small portion of Route 66 to assess how the road is operating and how effective it has been in its' early years of operation. Overall, solar road panels still have a long way to go, as there is plenty to discover about solar roadways and how they may evolve drastically over the next few years.

Works Cited

"Asphalt vs Solar Roadways." *Solar Roadways*, Weebly, 2016, solar-roadways.weebly.com/asphalt-vs-solar-roadways.html.

"Climate Change Indicators: U.S. Greenhouse Gas Emissions." *EPA*, Environmental Protection Agency, 17 Dec. 2016, www.epa.gov/climate-indicators/climate-change-indicators-us-greenhouse-gas-emissions.

"Costco Sustainability Building." *Costco*, Jan. 2018, www.costco.com/sustainability-buildings.html.

"Getting Credit for Surplus Energy." *PG&E*, Pacific Gas & Electric, Nov. 2018, www.pge.com/en_US/business/solar-and-vehicles/net-energy-metering/get-credit-for-surplus-energy/get-credit-for-surplus-energy.page

"History of Solar Energy in California." *Go Solar California*, 8 Oct. 2018, www.gosolarcalifornia.ca.gov/about/gosolar/california.php.

"How Much Does An Asphalt Driveway Cost?" *Improvenet*, CraftJack, 31 July 2018, www.improvenet.com/r/costs-and-prices/asphalt-paving-cost.

"Interview with Solar Roadways Inc." Personal Interview. 25 Nov. 2018.

Johny, Stephy, and Keerthi Susan John. "A Review on Solar Roadways: The Future of Roads." *IJRIER*, International Journal of Recent Innovation in Engineering and Research, 3 Mar. 2017, ijrier.com/published-papers/volume-2/issue-3/a-review-on-solar-roadways-the-future-of-roads.pdf.

Kulkarni, Alark A. "'Solar Roadways' - Rebuilding Our Infrastructure and Economy." *IJERA*, International Journal of Engineering Research and Applications, 2013, www.ijera.com/papers/Vol3_issue3/IJ3314291436.pdf.

Mehta, Ayushi, et al. "Solar Roadways - The Future of Roadways." *IARJSET*, International Advanced Research Journal in Science, Engineering and Technology, 1 May 2015, www.iarjset.com/upload/2015/si/ncree-15/IARJSET%2033%20P141.pdf.

Pacific Gas & Electric. (2017, May). *Electric Rates*. URL. https://www.pge.com/tariffs/electric.shtml. Accessed. May. 2017.

Shingate, Varsha Dadasanheb, et al. "IJARIIT." *IJARIIT*, International Journal of Advance Research, Ideas and Innovations in Technology, 2017, www.ijariit.com/manuscripts/v3i6/V3I6-1243.pdf.

"Solar Roadways Specifics." *Our Journey - SolarRoadways*, SolarRoadways Inc., 2016, www.solarroadways.com/Specifics/Numbers.